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Fieldwork

Scientists Set Sail to Map the Arctic Seafloor

By: Jessica Robertson, Deborah Hutchinson, Jonathan Childs, and Brian Edwards

American and Canadian scientists set sail this summer to map the Arctic seafloor and gather data to help define the outer limits of the continental shelf.

Each coastal nation may exercise sovereign rights over the natural resources of their continental shelf, which includes the seabed and subsoil. These rights include control over minerals, hydrocarbons, and sedentary organisms such as clams and coral.

Under international law, specifically the United Nations Convention on the Law of the Sea, every coastal nation automatically has rights over a continental shelf out to 200 nautical miles or to a maritime boundary. The Convention also states that a nation is entitled to continental shelf beyond 200 nautical miles if certain criteria are met—an area that is referred to as the "extended continental shelf."

The U.S. Geological Survey is the lead science agency for the United States in the 2010 U.S.-Canada Extended Continental Shelf survey. "In this expedition, Canada and the U.S. are working together to delineate the extended continental shelf in the Arctic to better determine where the Convention's criteria can be met," said USGS scientist **Brian Edwards**, chief scientist on the U.S. Coast Guard Cutter *Healy*.

The *Healy* will sail the Arctic from August 2 to September 6, 2010, meeting up with the Canadian Coast Guard Ship *Louis S. St-Laurent* at sea.

The ships will alternately break through the Arctic sea ice for each other. The *Healy* will map the shape of the seafloor using a multibeam echo sounder, and the *Louis S. St-Laurent* will collect multichannel seismic reflection and refraction data to determine sediment thickness.

This is the third year the United States

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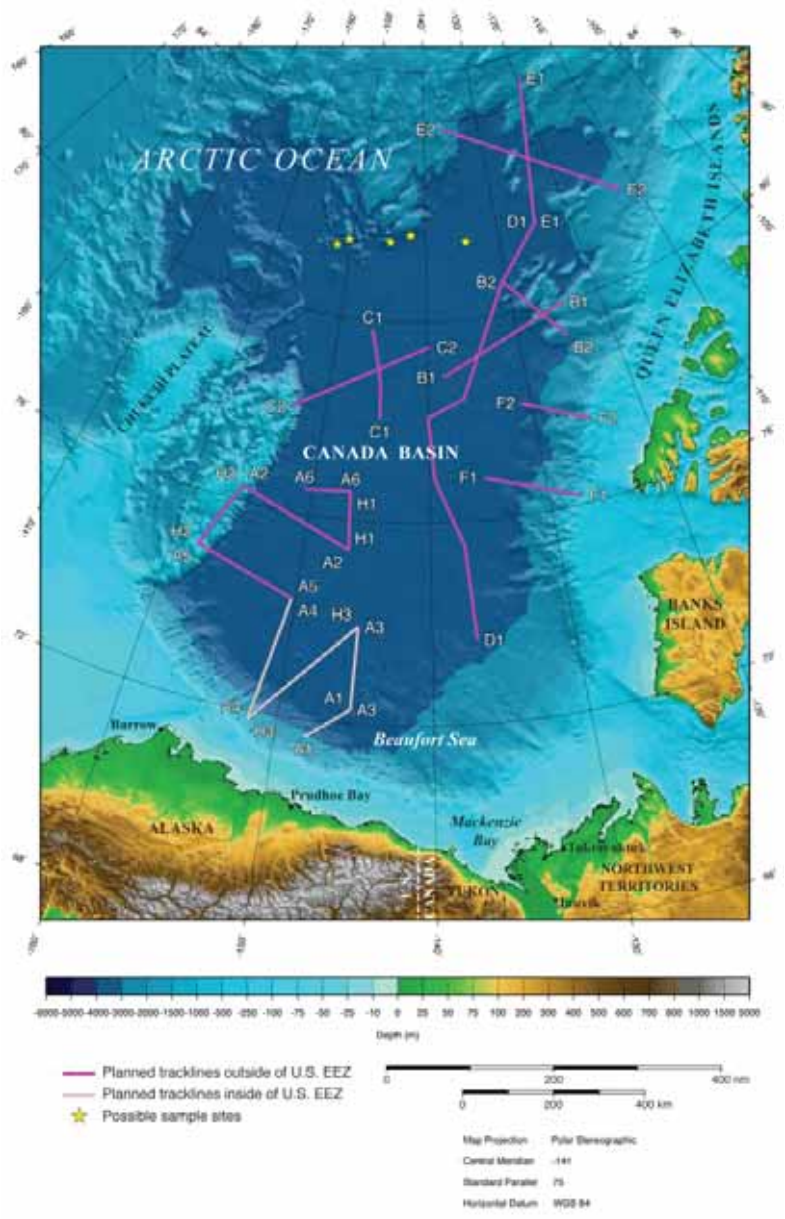

Planned tracklines for the 2010 U.S.-Canada Extended Continental Shelf survey. "EEZ" stands for Exclusive Economic Zone, which extends from a nation's coastline out 200 nautical miles (or to a maritime boundary with another nation). nm, nautical miles; km, kilometers.

Sound Waves

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Images: Please submit all images at publication size (column, 2-column, or page width). Resolution of 200 to 300 dpi (dots per inch) is best. Adobe Illustrator© files or EPS files work well with vector files (such as graphs or diagrams). TIFF and JPEG files work well with raster files (photographs or rasterized vector files).

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Fieldwork, continued

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The Coast Guard Cutter Healy. ***Photo credit: U.S. Coast Guard.***

and Canada have collaborated in extended continental shelf data collection in the Arctic. The United States has independently been collecting single ice-breaker data in the Arctic since 2003 in furtherance of the U.S. Extended Continental Shelf Project.

"The Arctic Ocean is an area of great interest for science, resource conservation, and possible economic development," said USGS scientist **Deborah Hutchinson**. "Because there is an area with considerable overlap between the U.S. and Canadian extended continental shelves, it makes sense to share data sets and work together in the remote and challenging environments of the Arctic Ocean."

"This is the last year working in the Canada Basin north of Alaska, and in 2011, we'll collect data together with Canada in the area north of the Canada Basin around the Alpha Ridge," said USGS scientist **Jonathan Childs**, who is leading the U.S. Interagency Task Force Seismic Data Operations Team.

Research is coordinated by the U.S. Extended Continental Shelf Task Force, a government-wide group headed by the U.S. Department of State. Participants in this Task Force include the U.S. Department of the Interior; U.S. Geological Survey; National Oceanic and Atmospheric Administration; U.S. Coast Guard; National Science Foundation; Joint Chiefs of Staff; U.S. Navy; U.S. Department of Energy; U.S. Environmental Protection Agency; Executive Office of the President; Bureau of Ocean Energy Management, Regulation, and Enforcement; and the Arctic Research Commission.

Watch a video podcast about this expedition at **http://www.usgs.gov/corecast/details.asp?ep=131**.

For additional information on this expedition as well as photographs and video from past cruises, visit the Extended Continental Shelf Project at **http://continentalshelf.gov/**.

Ocean Acidification: Research on Top of the World

By Ann Tihansky

The oceans currently absorb approximately one-third of total emissions of carbon dioxide (CO_2) generated by fossil-fuel combustion. As CO_2 is absorbed by the ocean, it forms carbonic acid and lowers the slightly alkaline (basic) pH of seawater. This suite of chemical changes is known collectively as ocean acidification. Lowered ocean pH alters the ability of many calcifying marine organisms to produce calcium carbonate skeletons and shells. Ocean acidification is an emerging global problem because, as CO_2 emissions continue, so will the lowering of ocean pH that may cause profound changes in marine food webs and global ecosystems. (See related *Sound Waves* articles at **http://soundwaves.usgs.gov/2009/11/**, **http://soundwaves.usgs.gov/2009/04/fieldwork2.html**, and **http://soundwaves.usgs.gov/2008/03/research.html**.)

The U.S. Geological Survey (USGS), along with other federal agencies, is working with the international scientific community to help standardize and compile information that adequately describes ocean chemistry trends and analyzes relations between these trends and carbon sources, cycles, and human activities. The USGS has been pioneering work to improve capabilities in measuring marine carbonate species and metabolic cycles that affect carbon compounds (**http://coastal.er.usgs.gov/flash/**), as well as characterizing CO_2 concentrations in a wide variety of marine environments (**http://coastal.er.usgs.gov/crest/**).

As part of that effort, USGS scientists are participating in a unique opportunity to sample the remote waters of the Arctic Ocean during the 2010 U.S.-Canada Extended Continental Shelf Survey research expedition on board the U.S. Coast Guard vessel *Healy* from August 2 to September 6, 2010. (See related article "Scientists Set Sail to Map the Arctic Seafloor," this issue.) By collecting CO_2 data and related chemical samples in the largely uncharted Arctic waters, scientists will fill important gaps of knowledge that will contribute to better understanding of the impacts of CO_2 on ocean chemistry, trends in ocean acidification, and

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USGS and University of South Florida (USF) scientists will be aboard the U.S. Coast Guard Cutter Healy*, which is designed to conduct a wide range of research activities.*

Scientists use a rosette off the deck of the Healy *to take Arctic Ocean water samples.*

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implications for climate change. "Models suggest that the Arctic is already undersaturated with respect to carbonate minerals during part of the year," said **Lisa Robbins**, USGS oceanographer. "Our data will provide important baseline information about this region that looks at marine carbonate chemistry; saturation states, dissolution potential and the role microbial communities play in carbon cycling."

"Shiptime research is very expensive, so 'piggy-backing' science missions is always a good idea if it can be arranged to the benefit of all parties," said **Robbins**. Working together in the Arctic region and collecting such robust datasets will likely serve multiple uses and lines of research. "When scientists coordinate science activities in close proximity to one another, it creates a rich environment for dialogue and exchange. As we work together, ideas are cross-pollinated and everyone involved develops improved understanding. These are the kind of synergistic benefits that will take place during this research cruise," said **Robbins**. It is likely that these benefits will continue to be realized long after the data have been collected.

A highly specialized, collaborative team has been assembled for the Arctic cruise and includes USGS senior scientists **Lisa Robbins** and **Kim Yates**, and University of South Florida's (USF) College of Marine Science Professor **Bob Byrne**, along with technicians **Chris Dufore** (USGS), and **Mark Patsavas** (USF), and research associate **Xuewu Liu** (USF). During the cruise, discrete water samples will be collected along track lines and through the water column. They will be analyzed both on board the *Healy* and back in the USGS laboratory in St. Petersburg, Florida. Additionally, state-of-the-art equipment pioneered by **Byrne's** laboratory will provide "flow-through" data on the concentrations of total carbon and carbon dioxide in seawater, measured as the partial pressure expressed as pCO_2, since it is in gas form. The system will also measure pH using highly precise spectrophotometric methods. For the first time, in-place measurement of carbonate ion concentrations will be attempted. Bacterial community samples will also be collected, along with nutrients, dissolved organic carbon, and oxygen and carbon isotope samples. USGS microbiologist **John Lisle** will analyze microbial samples. The team has been working for months preparing analytical and sampling equipment for the extended time at sea.

*USGS scientist **Kim Yates** (right) instructs students during a laboratory demonstration on ocean-acidification techniques in Woods Hole, Massachusetts.*

The USGS ocean acidification team–**Lisa Robbins**, **Kim Yates**, and **Chris Dufore**–participated in a high profile, first-of-its-kind, National Science Foundation (NSF)-sponsored short course on ocean acidification in November 2009 at Woods Hole Oceanographic Institution. **Yates** and **Dufore** demonstrated and taught spectrophotometric pH and alkalinity techniques, experimental techniques, and data analysis methods. **Robbins**, an invited member of the organizing committee for this unique short course, worked with the other members to develop the course content and agenda. **Yates** was chosen as one of 20 international expert scientists to lecture on specific topics in ocean acidification. **Yates** discussed manipulation of carbonate system parameters in ocean acidification experiments. The state-of-the-art analytical methods that she and **Dufore** demonstrated are used in the USGS laboratory in St. Petersburg, Florida.

This dataset will fill knowledge gaps in the global map of ocean carbon species and will be shared with the international scientific community. For more than 10 years, the USGS team has been working to characterize carbon species found in different marine environments. "We have detailed information from tropical waters, temperate waters, and open ocean as well as continental shelves. The data from the Arctic Ocean will give us the ability to compare trends from the equator to those observed at the Earth's poles," said **Kim Yates**, research oceanographer.

Understanding climate change in the Arctic, including ocean acidification, is of high priority to the U.S. Department of the Interior's **Secretary Salazar**. Potential impacts from observed trends will have broad global influence affecting the seafood industry, coral reef health, sedimentation patterns, carbon management policies and related economic impacts, as well as future climate. USGS science is critical for making informed policy decisions and in developing strategies to address ocean acidification with the global community.

Robbins participates on the Interagency Working Group on Ocean Acidification (IWG-OA) (**http://www.nopp.org/committees/iwg-op/**, **http://www.nopp.org/2010/newly-established-ocean-acidification-task-force-holds-first-meeting/**). The IWG-OA was formed as a result of the Federal Ocean Acidification Research and Monitoring (FOARAM) Act of 2009, which calls for an interagency working group (IWG) under the Joint Subcommittee on Ocean Science and Technology (JSOST) to develop a strategic research plan and to coordinate Federal ocean acidification activities. This Act also calls for the establishment of a Federal ocean acidification program. An initial report from the IWG-OA was sent to Congress in

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March 2010, and the Strategic Plan is currently being written, with intent to deliver it to Congress in 2011.

The USGS also participates in the Arctic Mapping and Assessment Program, part of the Nordic Council (**http://www.arcticportal.org/science/**). **Robbins** and **Yates** worked with other scientists to co-author an Arctic Ocean Acidification Scoping paper. **Robbins** presented the Scoping paper to the Arctic Monitoring and Assessment Program (AMAP) in February 2010.

The data from this research cruise will be shared with AMAP and the rest of the global scientific community. They will help expand knowledge and capabilities of scientists worldwide to understand future ocean and climate trends and impacts.

Follow the research team on the *Healy* at **http://continentalshelf.gov/.**

More information about the expedition can be found at **http://www.icefloe.net/reports_healy.html** and **http://www.uscg.mil/pacarea/cgcHealy/**.

*USGS technician **Chris Dufore** demonstrates pH and alkalinity techniques at the ocean-acidification class in Woods Hole, Massachusetts.*

Further information on interagency science bodies and committees addressing the ocean acidification problem can be found at **http://www.us-ocb.org/** and **http://www.nopp.org/committees/iwg-op/**.

Tracking Coral Larvae to Understand Hawai`i Reef Health

By: Curt Storlazzi

Scientists can predict almost to the hour when the reef-building "rice coral" (*Monitpora capitata*) off O'ahu will spawn, but no one knows where the resulting floating coral larvae go.

From June 11 to 16, the U.S. Geological Survey (USGS), the University of Hawai'i (UH) at Manoa's Kewalo Marine Laboratory, and the community group Malama Maunalua conducted an experiment along O'ahu's south shore in an effort to better understand why certain reefs in Maunalua Bay are doing well and others are doing poorly.

Maunalua Bay is a linked watershed-reef complex ("ahupua'a" in Hawaiian) of concern to the U.S. Coral Reef Task Force's Hawai'i Local Action Strategy (USCRTF-LAS) and is degraded by polluted runoff and sediment, invasive algae, and unsustainable harvesting. The reduced quality of the water and the seabed affect not only the corals in the bay, but also the ability of larvae from elsewhere to settle on the seabed and replenish depleted populations (the "recruitment" process). If new corals are unable to replace those that die, the reefs will eventually disappear, along with the other associated marine resources.

A colony of the reef-building coral Montipora capitata*, which was the focus of this USGS study. The field of view is approximately 1 m across. Photograph by **Curt Storlazzi** (USGS).*

Community-based efforts, coupled with American Recovery and Reinvestment Act (ARRA) restoration efforts to remove invasive algae are focused on improving coral and fish resources. However, coral reef recovery requires effective new recruitment, and Maunalua Bay characteristically has a low abundance of coral recruits. There is uncertainty as to whether the lack of recruitment is due to a low supply of coral larvae in the bay or

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to anthropogenic stressors that impair the recruitment success.

To help resolve this question, a multipartner experiment to investigate coral spawning and recruitment in Maunalua Bay was conducted this past June. The study focused on the coral species *Monitpora capitata*. It is a major reef builder in Hawai'i, and the large size of the planula (free-swimming) larvae (0.75–1.50 mm) allows optical and acoustic detection of the larvae during the spawning event. The peak spawning periods for *Monitpora capitata* in Hawai'i are around the summer new moon between 9:00 and 11:00 PM Hawaiian Standard Time (HST). This year, *Monitpora capitata* spawning began the evening of Saturday, June 12th.

Scientists **Curt Storlazzi**, **Josh Logan**, **Kathy Presto**, **Tom Reiss**, and **Pete Dal Ferro** (all USGS, Santa Cruz) collected information on circulation and water-column properties of Maunalua Bay during summer spawning conditions, complementing a dataset collected during the 2008-2009 winter. They were hosted by and collaborated with **Robert Richmond** (UH Kewalo Marine Laboratory), his students, and other staff at the Kewalo Marine Laboratory. Team members using scuba equipment conducted nightly fixed-station monitoring of select coral colonies before, during, and after spawning to determine the proportion of coral colonies spawning during the event. Satellite-tracked Global Positioning System (GPS) drifters were deployed above select reefs after spawning each night to track the movement of the buoyant coral larvae to determine if they are being retained in or carried out of Maunalua Bay. The team also surveyed current speeds and directions along more than 20 km of transects and water-column properties at more than 15 locations daily by boat before, during, and following the June spawning event. These surveys will provide information on hydrography of the bay during summer conditions and will allow scientists to identify the presence of eddies and shear zones in the bay that help to retain larvae or sediment, nutrients, or contaminants.

*A satellite-tracked GPS drifter off Diamond Head, O`ahu, just before recovery. The electronics are housed in the orange sphere, the large white diamond is the drogue that is calibrated to make the entire package drift at the same speed as the currents. Photograph by **Josh Logan** (USGS).*

***Pete Dal Ferro** (left) and **Curt Storlazzi** (right) preparing to enter the water at 9 PM HST to monitor the coral spawning in Maunalua Bay. Photograph by **Kathy Presto** (USGS).*

The relatively short-duration vessel surveys are being supplemented by longer-term measurements of currents and water-column properties at a number of fixed stations in the bay from June through the end of September. For the June vessel surveys and the four longer-term fixed stations, the team used 600-kHz acoustic Doppler current profilers (ADCPs) to collect acoustic backscatter data. These data allowed them to image the *Monitpora capitata* larvae and quantify the relative intensity of spawning events. Collectively, the combination of mobile vessel surveys and fixed instrument deployments put the intensive June measurement efforts in the context of the full June-September *Monitpora capitata* spawning season. Once scientists understand the circulation, larval dispersal patterns, and "connectivity" between reefs, areas where reef recovery efforts should be focused can be identified.

While on-the-reef studies were taking place, **Renee Takesue** (USGS, Santa Cruz) worked with staff and volunteers from Malama Maunalua to collect sediment samples from the coral reef flat and the adjacent watersheds to determine the source(s) of the terrestrial sediment on the reef flat using geochemical means. **Renee** was joined on the reef flat by **Cheryl Hapke** (USGS, Woods Hole), who was collecting ground-truthing information for her effort to use historical aerial imagery to detect and map changes on the reef flat over the past 70 years.

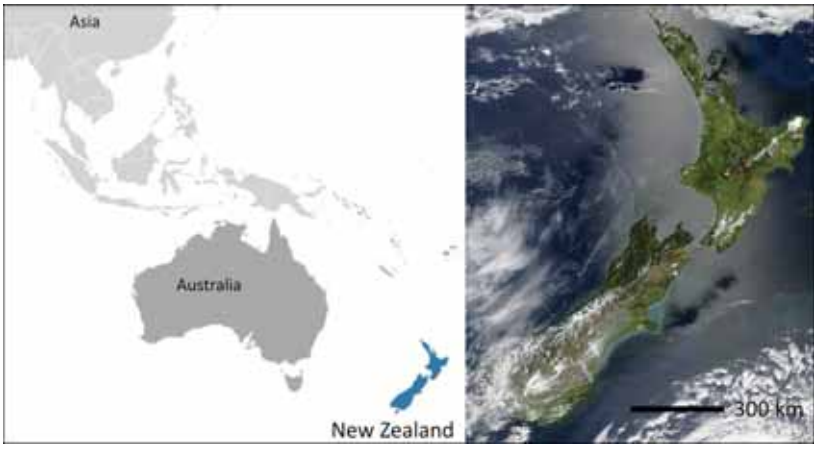
At a reception hosted by Malama Maunalua, USGS scientists gave a public lecture for the community. The USGS and UH researchers were also interviewed by the local CBS affiliate (a nightly news "top story"), Hawaiian Public Radio, and the *Star-Advertiser*, Hawai'i's largest newspaper. See "Scientists seek data as corals get frisky" (**http://www.staradvertiser.com/news/20100611_Scientists_seek_data_as_corals_get_frisky.html**), "Secret love lives of Oahu's reefs unveiled" (**http://www.hawaiinewsnow.com/Global/story.asp?S=12638586**), and "Tracking Coral Larvae to Understand Hawai'i Reef Health" (**http://www.sciencedaily.com/releases/2010/06/100609092658.htm**).

Fieldwork in New Zealand: Comparisons Between Northern and Southern Hemisphere Wetlands

By Karen L. McKee

Fieldwork on the North Island of New Zealand is contributing to a more global view of how wetlands function and how they may respond to climate change and other human-driven impacts. USGS scientist **Karen McKee** spent 5 months conducting research alongside New Zealand colleagues and other collaborators.

From January 10 to May 25, 2010, **McKee** participated in two projects aimed at a better understanding of wetlands in both the Southern and Northern Hemispheres. One project focused on freshwater wetlands in New Zealand and their vulnerability to nutrients; the other investigated the southernmost populations of mangrove, a subtropical/tropical coastal tree, and how climate change and other factors may affect mangrove expansion where their distribution overlaps with temperate salt marsh.



Left: location map modified from U.S. Central Intelligence Agency locator map of New Zealand (https://www.cia.gov/library/publications/the-worldfactbook/geos/nz.html); right: satellite image from Visible Earth, NASA (http://visibleearth.nasa.gov/view_rec.php?id=6743).

Where is New Zealand and What Was it Like to Do Fieldwork There?

New Zealand, which consists of two main islands and numerous smaller islands, is located in the Southern Hemisphere about 1,250 miles southeast of Australia and 1,500 miles north of Antarctica. The country is characterized by dramatic topography (from low-lying coastal areas to the peaks of the Southern Alps) and a complex climate (warm subtropical in the north, cool temperate in the south, severe alpine in mountainous regions). This varied landscape is contained within only 103,483 square miles (about the size of Oregon) and has a human population of just over 4 million. New Zealand straddles the Pacific and Australian tectonic plates and is characterized by periodic earthquakes and volcanism. Because of its long isolation from the rest of the world, New Zealand boasts an extraordinary biota—about 80 percent of its plant species are endemic. However, since European settlement, much of the native forest has been cleared, and many nonnative species of plants and animals have been introduced.

Fieldwork in New Zealand was often challenging. Researchers had to traverse large expanses of pasture and dodge grazing livestock to access freshwater wetlands, which were often located in isolated pockets far from roads and navigable waterways. Access to mangrove study sites along the coast required considerable hiking and was complicated by the large (6-9 ft) tide range—researchers had to plan carefully to avoid being stranded. Fortunately, there are few dangerous animals in New Zealand, ticks and tick-borne diseases are rare, and there is only one species of venomous spider. Except for stinging nettles (*Urtica* species), there are few poisonous plants.

Why Study Wetlands in New Zealand?

Temperate wetlands in the Northern Hemisphere have been well studied, and this research underlies much of what is known about wetland structure and function. In contrast, much less is known about wetlands in the Southern Hemisphere, particularly in geographically isolated locations such as New Zealand. New Zealand wetlands contain unique indigenous flora and fauna, which are found nowhere else. These wetlands provide many of the same goods and services as do northern, temperate wetlands and are consequently important natural re-

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*USGS scientist **Karen McKee** (right) and **Scott Bartlam** (left) of Landcare Research trek across pastures and steep slopes to reach their destination—the Toreparu freshwater wetland (arrow) on the North Island of New Zealand. The Tasman Sea is just visible on the horizon.*

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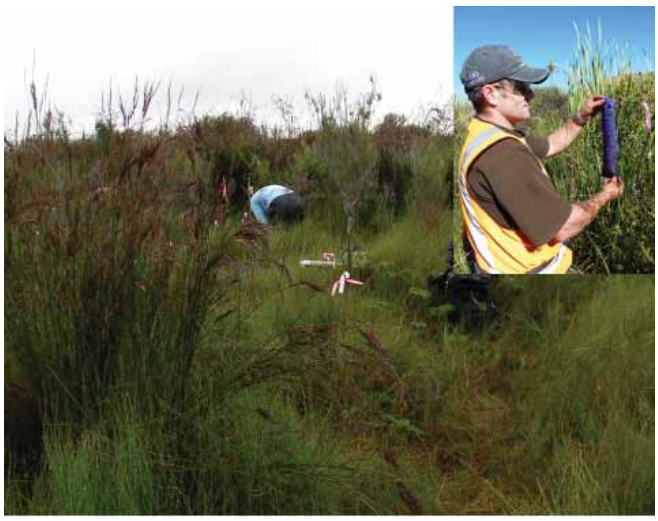
sources. Also, as in many other locations worldwide, New Zealand has lost a substantial portion of its wetlands to fragmentation, conversion to other uses, nutrient enrichment, and invasive species.

This study will help determine to what extent our understanding of biodiversity and ecosystem processes, based on northern, temperate wetlands, can be applied to New Zealand and other Southern Hemisphere locations. Of perhaps greater importance, information from Southern Hemisphere wetlands can be used in conjunction with that from Northern Hemisphere to develop a broader database with which questions regarding resilience and impacts of global change can be addressed at a broader scale. This type of information is particularly needed to predict how wetlands worldwide will respond to climate change, sea-level rise, and eutrophication (the process by which a body of water becomes enriched in dissolved nutrients that stimulate the growth of aquatic plant life, commonly resulting in excessive algal blooms and the depletion of dissolved oxygen).



New Zealand and USGS scientists are studying how nutrient inputs are affecting freshwater bogs, especially peat formation. ***Scott Bartlam*** *(inset) is holding a root ingrowth bag, which will be used to measure belowground (root) production.*

Effects of Nutrients on New Zealand Freshwater Wetlands

McKee joined an international team of scientists led by Landcare Research, one of several Crown (government) Research Institutes in New Zealand, to investigate effects of nutrient enrichment on freshwater wetlands. Recent land-use conversion to dairy farming has greatly promoted polluted runoff into wetlands and invasion by weeds. Wetlands in the United States are similarly threatened by nutrient enrichment and invasive species, although the species involved as well as pollution sources and extent of influence may differ.

According to **Bev Clarkson** of Landcare Research, the goal of the New Zealand research program is to "improve management and restoration strategies for landowners, managers, and policymakers." To address this goal, research is focused on gaining a "functional understanding of how modification of water and nutrient regimes impacts biodiversity, cultural values, and ecosystem services in a range of wetland types." A unique aspect of this research program is its explicit involvement of native Māori in restoration case studies, development of cultural indicators, training of emerging researchers, and development of end-user products, such as a Web-based handbook on restoration of cultural wetlands.

McKee is participating in a study of freshwater wetlands to determine if they are functionally similar to temperate wetlands in the Northern Hemisphere, despite floristic differences. The study involves experimental additions of nutrients (nitrogen

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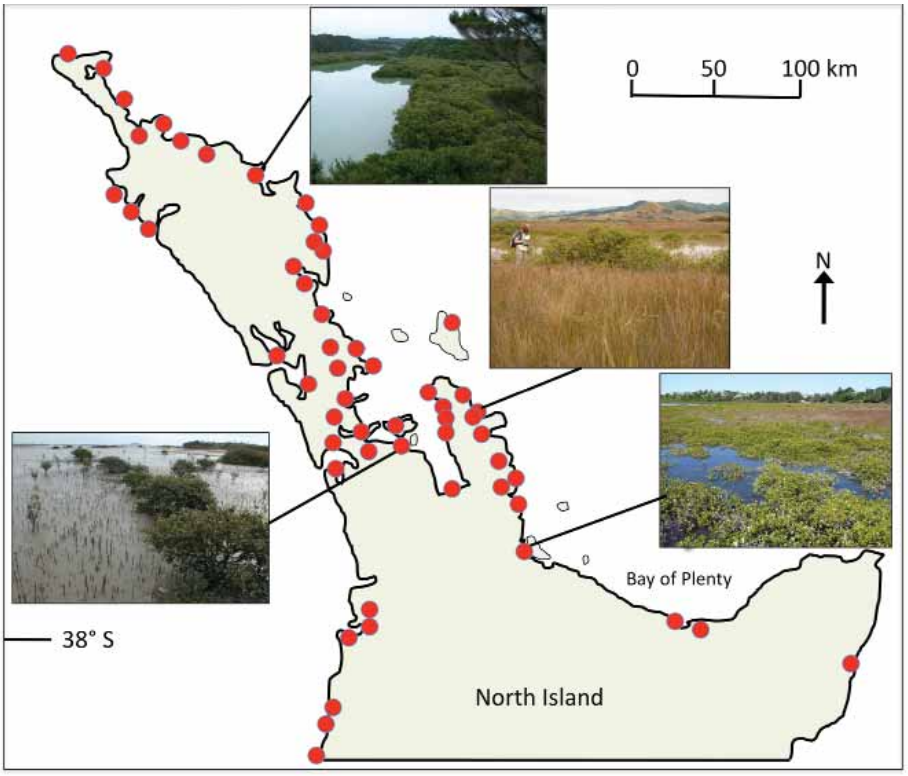


*Locations (red dots) of mangrove (*Avicennia marina *subsp.* australacasica*) populations in New Zealand (modified from Morrisey and others, 2007). Near the southernmost limits of distribution, mangrove growth is stunted owing to more frequent frost and shorter growing season.*

(New Zealand continued from page 8)

and phosphorus) to wetlands at different successional stages and hypothesized sensitivity to enrichment.

McKee's role is to provide expertise in assessing belowground (roots) responses to nutrients by wetland plants of New Zealand and to participate in and advise on other aspects of the research. During this initial fieldwork, **McKee** and other project participants began measurements of belowground productivity, which will be completed in 2011.

A Comparison of Mangroves at Northern and Southern Limits of Distribution

McKee also participated in a second project, which focused on coastal wetlands and involved colleagues from the National Institute for Water and Atmospheric Research (NIWA) (New Zealand), the University of Queensland (Australia) and the Smithsonian Institution (United States). Fieldwork on this project was initiated several years ago and assessed nutrient controls on mangroves in the Southern Hemisphere (Australia and New Zealand).

New Zealand has a single indigenous species of mangrove, *Avicennia marina* subsp. *australacasica*, which is restricted to the North Island of New Zealand, New Caledonia, Lord Howe Island, and the southern tip of Australia. Its Northern Hemisphere counterpart, *Avicennia germinans* (black mangrove), grows at its northernmost limits in Louisiana, where **McKee** also has study sites. At their northern and southern limits, mangroves intergrade with temperate marsh plants, with which they compete for space, light, and nutrients. In both settings, mangroves are expanding in area, although the causes for expansion appear to differ.

In previous research, **McKee** has examined effects of elevated carbon dioxide on *A. germinans* in Louisiana and effects on competition with salt marsh species; she and her colleague **Jill Rooth** published a paper on this subject in *Global Change Biology* (2008, vol. 14, p. 971-984, **http://dx.doi.org/10.1111/j.1365-2486.2008.01547.x)**. In addition, **McKee** coauthored a book chapter on salt marsh-mangrove interactions in Australia and the Americas for inclusion in *Coastal Wetlands, An Integrated System Approach*, published in 2009 by Elsevier (**http://www.elsevier.com/wps/find/bookdescription.cws_home/716674/description**).

Restoration of peat mine areas in New Zealand is being encouraged by scientists in partnership with private land owners. Researchers are investigating ways to promote rapid revegetation by native peat-forming species and to discourage weed invasion. Clockwise from top left: satellite view (Google Earth) of the Hauraki Plains (red dot on inset index map) with extensive peat deposits (dark brown = active peat mine); ground view of peat mining operation; initiation of restoration by seeding; restored bog with native plants.

During fieldwork in New Zealand, **McKee** examined characteristics of mangroves for comparison with mangroves at their northern limits along the Gulf of Mexico. She traveled along both coasts of the North Island in New Zealand conducting measurements and making observations of mangroves and associated marsh vegetation.

Wetland Restoration in New Zealand

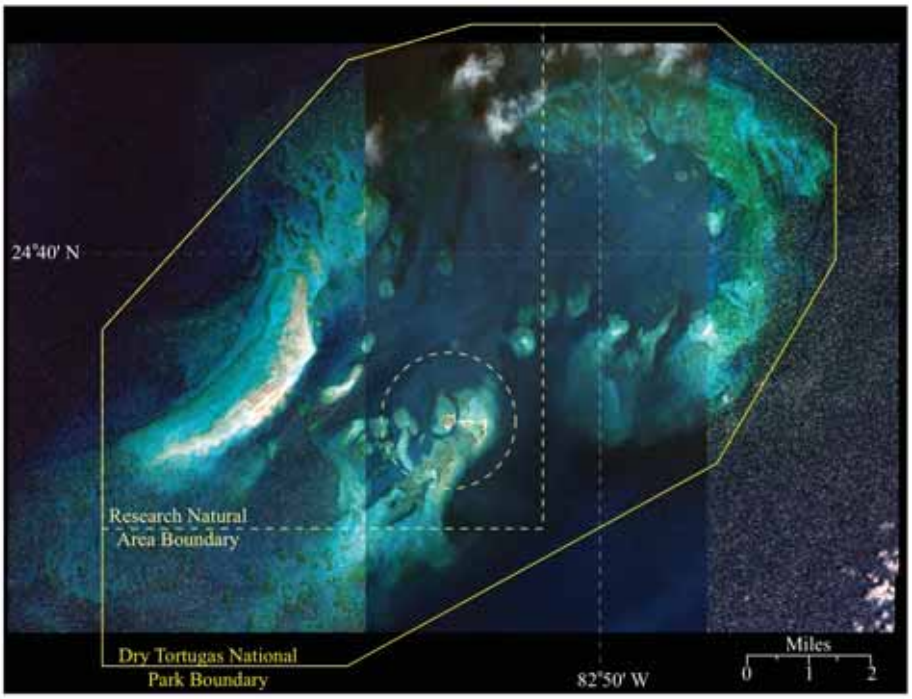
McKee also visited wetland restoration sites to observe methods and learn about cooperative efforts between government researchers and private companies. Peat mining, which involves surface excavation of peat bogs, is an important industry in New Zealand. Some mining companies are cooperating with New Zealand scientists to restore the native bog vegetation in mined areas to allow for future peat formation. **McKee** visited one mine in the Hauraki Plains region, where researchers had conducted a study to determine the best planting, fertilization, and cultivation techniques to promote rapid revegetation by the primary peat-forming plants and to minimize invasion by weeds. The results of this study will assist the mining operation in designing protocols for postharvest restoration.

By studying and comparing diverse wetlands, USGS scientists can develop more accurate models to predict future changes due to human activities as well as to natural disturbances. Research on wetlands outside of the United States, especially with respect to global change factors, is necessary to fully understand and predict how wetlands in general may respond in the future. By identifying how differences and similarities in structure and function influence wetland resilience, scientists can better predict how specific wetlands in the United States will fare in the future and to design appropriate management and restoration plans. In addition, participation in international research projects leads to new ideas and methods for protecting and conserving the Nation's natural resources.

Dry Tortugas National Park: a Unique Setting for USGS Marine Research

By Matthew Cimitile

This is the first in a series of articles looking at Coral Reef Ecosystem Studies research projects taking place in Dry Tortugas National Park. Stay tuned for the next edition of Sound Waves *in which we look at ocean acidification and coral calcification.*



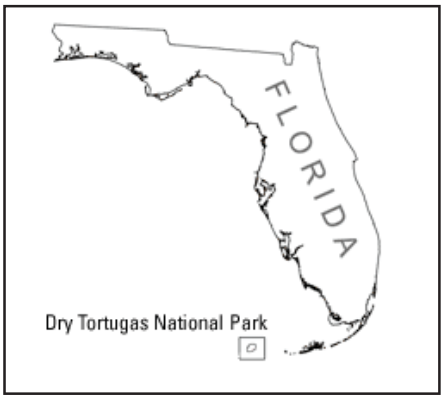
Consisting mostly of water and submerged land, Dry Tortugas National Park is home to abundant wildlife and important aquatic ecosystems and is a valuable location for scientific research.

About 70 miles west of Key West, at the terminus of the Florida Keys, lies a cluster of tiny islands. These islands and the 100 square miles of surrounding water constitute Dry Tortugas National Park. Protected by the U.S. National Park Service since 1935, this isolated area in the southeastern Gulf of Mexico is rich in marine life, making it a valuable location for scientific research. Scientists from the U.S Geological Survey (USGS) Coral Reef Ecosystem Studies (CREST) Project in St. Petersburg, Florida, conduct field studies in the Dry Tortugas to monitor and study the health of shallow-water reef environments and to improve our understanding of global issues such as climate change and ocean acidification.

The various research activities and remote location of the National Park require detailed coordination and logistical planning. Research teams spend days traveling and rely on the National Park Service for accommodations—often on board the 110-ft M/V *Fort Jefferson*, operated by Captains **Clayton "Blue" Douglass**, **Janie Douglass**, and **John Spade**. With the excellent support of the vessel's crew, scientists eat, sleep, and work round the clock setting up equipment, collecting data, and conducting surveys for as much as two weeks at a time.

"Tortugas work takes a lot of logistical planning," said USGS research ecologist **Kristen Hart**. "We use the National Park Service ship a lot. We work with the captains; we plan out our schedules, and they work to accommodate our needs and crazy work hours. We often need to have all our equipment and permits in place, sometimes months in advance."

The Dry Tortugas offers a unique research setting away from human activities. This makes it an ideal control site to compare to other areas where significant local-scale impacts on natural resources have taken place. Scientists with the CREST project have been working in the area for several years. Current tasks include research on coral calcification rates, monitoring coral reef community metabolism, investigating coral disease causes and processes, using historical coral core data to assess past ocean chemistry and temperature, and mapping and monitoring benthic habitats. This last task is overseen by USGS oceanographer **Dave Zawada**.



Index map showing the location of Dry Tortugas National Park.

Detailed maps are essential to efforts for conserving and managing ecosystems. Characterizing the composition and condition of benthic habitats provides a basis for assessing changes and monitoring the progress of restoration efforts. To collect such data, **Zawada** developed and operates a noninvasive observing system called the Along-Track Reef-Imaging System (ATRIS), which simultaneously acquires geo-located, color digital images and water-depth measurements. ATRIS can be deployed either from an adjustable pole mounted to the side of a boat ("shallow" configuration) or from a towed vehicle at depths of 27 m ("deep" configuration). The same camera and acquisition software are used for both operating modes.

"ATRIS provides us with information about the condition and type of substrate. From transects over an area, we can start to obtain estimates of the percent coverage and abundance of corals, sponges, vegetation, and other organisms on the seafloor. We can also get information pertaining

(Dry Tortugas continued on page 11)

(Dry Tortugas continued from page 10)

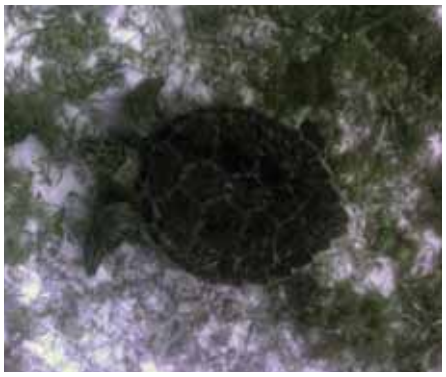
to the physical state of the habitat," said **Zawada**.

ATRIS images can be combined to create an image mosaic, allowing comparisons to previous ATRIS datasets of the same area to track changes over time. This capability is particularly useful with the possibility of oil impacting marine habitats. In 2009, **Zawada** and his team used ATRIS to map 163 km of seafloor in Dry Tortugas National Park, yielding nearly 460,000 color digital images. Should oil from the Deepwater Horizon leak reach the Park, this pre-event image collection establishes a baseline for evaluating oil impacts.

In the Dry Tortugas, ATRIS images are also being used to study and monitor the foraging, grazing, and transiting of threatened and endangered sea turtles. Green, hawksbill, and loggerhead sea turtles are being tagged and tracked to determine spatial and temporal habitat-use patterns. ATRIS data are used to determine the amount of time sea turtles spend in and around various habitats and zones. Blood and tissue samples are also collected from turtles to gain important dietary and genetic material. Together, the information is used to track the whereabouts and conditions of these endangered marine species.

Deep ATRIS is a critical tool used in characterizing the preferred habitat of endangered and threatened turtles in the Dry Tortugas.

Zawada and **Hart** recently submitted their first manuscript, using ATRIS to map areas **Hart** had determined were core-use zones for loggerhead females during the time in between successive nests, called the internesting period. Females usually lay a nest every two weeks during a nesting season, which typically occurs from May through early August in the Dry Tortugas. This year, **Zawada** and **Hart** will continue their ongoing research, making observations and captures near the end of the nesting season in late July.❁



A green sea turtle, captured photographically with deep ATRIS, navigates through vegetation on the seafloor in the Dry Tortugas in 2009.

This sandy beach is a prime spot for turtle nesting in Dry Tortugas National Park.

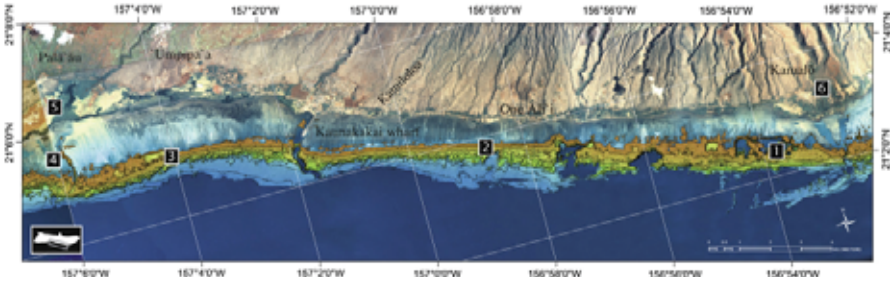
Coral Records of Sediment Input to the Fringing Reef of Moloka`i, Hawai`i

by: Nancy G. Prouty

Pollution to coral reef ecosystems is perceived to be widespread. Anecdotal evidence suggests the threat is increasing. However, without continuous measurements of sediment concentration and coral cover, it is difficult to evaluate the quantitative impact of sediment concentrations on coral ecosystems over many decades. A new study of coral geochemistry provides one method to close this gap.

Because terrestrial runoff carries sediment, nutrients, and pollutants, there are considerable threats to the health and

(Coral Records continued on page 12)

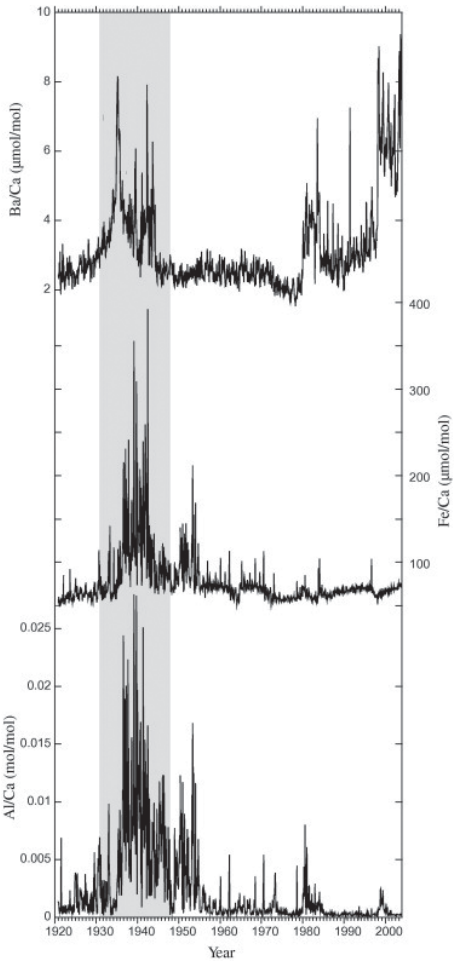


View of south Moloka'i reef flat from Pala'au to Kamalo derived from a combination of aerial photography and high-resolution bathymetric data. The four coral drilling sites are labeled 1-4 from east to west (Kamalo, One Ali'i, 'Umpipa'a, and Pala'au, respectively). The mangrove forest near Pala'au (5) is also marked. Relative depth below mean lower low water is depicted in color, with orange being the shallowest and blue the deepest. Isobath interval is 5 m.

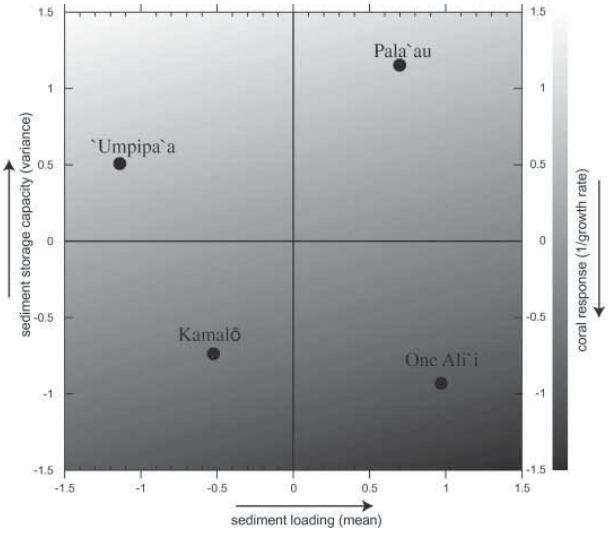
(Coral Records continued from page 11)

resilience of corals. Increased sediment concentrations in the water and on the seabed may bury coral in place, reduce its ability to recruit (add new corals to the population), reduce the amount of light available for photosynthesis, and promote harmful algal growth—ultimately leading to changes in species composition and reduced coral growth.

The watersheds of the Hawaiian Islands have experienced land-use changes over the past 200 years. Cultivation, overgrazing, and wildfires have exposed fine volcanic sands, silts, and clays to erosion. The fringing reef off the south coast of Moloka‘i is widely recognized as one of the most impacted large coral ecosystems in Hawai‘i. Anecdotal evidence suggests the level of sediment on the reef has increased over the past several decades. This has prompted several U.S. Geological Survey (USGS) studies aimed at understanding the dynamics of sediment transport and its impact on coral reef health. See “The Coral Reef of South Moloka‘i, Hawai‘i—Portrait of a Sediment-Threatened Fringing Reef,” U.S. Geological Survey Scientific Investigations Report 2007-5101, edited by **Michael Field**, **Susan Cochran**, **Josh Logan**, and **Curt Storlazzi** (**http://pubs.usgs.gov/sir/2007/5101/**).



Coral records of Ba/Ca, Fe/Ca, and Al/Ca from the ‘Umpipa‘a record (1921-2005) capture the increase of terrigenous input during the mid-1930s (shaded region), presumably linked to a rapid mangrove expansion from 1915 to 1940 as a result of the Hawaiian Homestead lands opened to farming.



Theoretical model indicating gradients of sediment loading (coral Ba/Ca variance) and sediment storage capacity (mean coral Ba/Ca) and relative coral response (inverse of average coral growth rates). Those sites with elevated sediment loading and low sediment storage (for example, One Ali‘i) yield a higher coral response, whereas coral growth rates from sites with a greater capacity to store sediment (for example, Pala‘au) will not be as greatly impacted.

To test the hypothesis that sedimentation has increased over time, the present study used barium-to-calcium (Ba/Ca) ratios as a measure of sediment input to the reef on timescales of decades to centuries. Ba is desorbed and incorporated into the coral skeleton upon contact with seawater in amounts that depend on the concentration of clay and silt particles in the water column. Because Ba is sourced from the fine-grained components of terrestrial soil, it is a proxy for the amount of land-based sediment in the coral environment.

Working with **Malcolm McCulloch** and **Stacy Jupiter** (Australian National University), USGS scientists **Nancy Prouty**, **Mike Field**, **Curt Storlazzi**, and **Josh Logan** drilled and recovered coral cores from four sites along the fringing reef of the south-shore of Moloka‘i from living scleractinian (stony) corals (*Porites lobata*). The cores were analyzed for their chemical content to determine if the level of sediment on the reef has increased over the last several decades.

The Effective River End-Member (EREM) concentration was calculated to gain information about the dissolved or solid Ba concentration in the contributing rivers. The coral Ba concentration was used to calculate the Ba EREM concentrations from the closest point of river discharge, the Kawela Gulch. This value was consistent with upstream Kawela storm runoff samples collected in November 2007 following peak river discharge. Baseline Ba EREM calculations were also consistent with dissolved Ba concentrations in seawater measured offshore from the Kawela Gulch during a nonstorm sampling event. Comparable values of the coral calculated Ba EREM concentrations relative to both empirical storm and baseline Ba concentrations suggest that coral Ba/Ca ratios proportionately record nearshore dissolved Ba concentrations off the South Moloka‘i reef flat.

Second-order processes such as resuspension, however, can significantly alter the barium budget in the nearshore environment. Field observations by USGS scientists **Curt Storlazzi**, **Kathy Presto**, and **Mike Field** and academic colleague **Andrea Ogston** (University of Washington) suggest that during windy afternoons and evenings, suspended sediment concentrations can be in excess of those reported to be injurious to corals. This is particularly

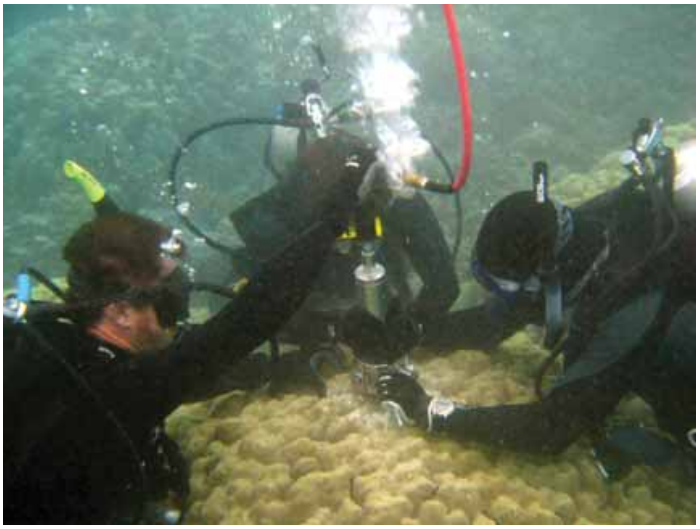
(Coral Records continued on page 13)

(Coral Records continued from page 12)

true during storms and under swell conditions when waves propagating onto the reef flat during high tide resuspend large amounts of sediment and subsequently alter the marine Ba budget.

This study shows that controls on coral Ba/Ca ratios are a combination of sediment supply (upslope sources), sediment accommodation space (storage capacity), and resuspension. For example, coral Ba/Ca ratios were found to vary inversely to growth rate if sediment supply was relatively constant. If sediment storage capacity is sufficient (for example, via mangrove forest) and allows for periods of "recovery" when turbidity levels are reduced, then coral Ba/Ca values return to baseline values and overall growth rates are not reduced. Therefore, variability in coral Ba/Ca along the south shore of Moloka'i can be explained by differences in sinks as well as sources.

For example, coral Ba/Ca variability at 'Umpipa'a, a coring site on the western side of the reef flat, is sensitive to pulses of sediment discharge associated with nearby coastal modification and episodic releases of sediment from the mangroves when its carrying capacity is breached. In particular, Ba/Ca ratios increased significantly in the mid-1930s and were accompanied by elevated Fe/Ca and Al/Ca ratios during that time, as well as a reduction in growth rate. Historical aerial photographs show a rapid mangrove expansion from 1915 to 1940, when shoreline progradation rates (rates at which the shoreline was being built seaward) reached a maximum of 27 m/year (read more about mangroves and their effects on coastal change in chapter 16 of "The Coral Reef of South Moloka'i, Hawai'i—Portrait of a Sediment-Threatened Fringing Reef"). Accelerated progradation rates from 1915 to 1940 are not surprising because, by the 1920s, much of the Ho'olehua Saddle was set aside as Hawaiian Homestead lands and was opened to farming. With the muds enriched in metals such as Fe and Ba, progradation of the shoreline most likely acted as a mobile mud-belt source to the reef.



USGS Scientists (left to right) ***Josh Logan***, ***Nancy Prouty***, *and* ***Curt Storlazzi*** *recovering coral cores from Moloka'i, Hawai'i in order to reconstruct sediment impacts to the fringing reef over the last century.*

With this information, a theoretical model can be constructed indicating gradients of sediment loading (source) and sediment storage (sink) and relative response of coral growth. This information can help resource managers calculate trajectories of coral reef health related to future land-use change and climate change, because both processes will affect the supply and storage of sediment to the reef flat.

The complete reference for the new publication is: Prouty, Nancy G., Field, Michael E., Stock, Jonathan D., Jupiter, Stacy D., and McCulloch, Malcolm D., in press, Coral Ba/Ca records of sediment input to the fringing reef of the southshore of Moloka'i, Hawai'i over the last several decades: Marine Pollution Bulletin, 10.1016/j.marpolbul.2010.05.024 [**http://dx.doi.org/10.1016/j.rpolbul.2010.05.024**].

Save the Date for Coastal Zone 2011!

Coastal Zone 2011 will be held July 17-21, 2011, at the Hyatt Regency in Chicago, Illinois. In keeping with the location and acknowledging the changing coastal and ocean landscape, the overall conference theme is "Winds of Change: Great Lakes, Great Oceans, Great Communities." Sessions will be organized around four conference tracks: Planning for Resilient Great Lakes, Coasts, and Ecosystems; Healthy Habitats, Healthy Coastal and Great Lakes Communities; Observing, Modeling, and Monitoring; and Vibrant Coastal, Great Lakes, and Marine Economies. Abstracts for panel and oral presentations, posters, cafe conversations, and training workshops are due on October 8, 2010, and must be submitted online.

U.S. Geological Survey (USGS) scientists have participated in this meeting in the past (see related article in *Sound Waves*, September 2007, http://soundwaves.usgs.gov/2007/09/meetings.html) and USGS scientists **Ann Tihansky**, **Norm Granneman**, and **Susan Russell-Robinson** are members of the Coastal Zone 2011 planning team.

Conference partners include the National Oceanic and Atmospheric Administration, the Department of the Interior, the U.S. Environmental Protection Agency, the U.S. Army Corps of Engineers, and the Illinois Department of Natural Resources. As it becomes available, more information about the conference program and abstract submission will be posted at **http://www.doi.gov/initiatives/CZ11/index.htm**.

USGS Scientists Raise Coastal Change Awareness at Community Hurricane Expo

By Allison Wilkinson

The Science Center of Pinellas (**http://www.sciencecenterofpinellas.org/**) invited U.S. Geological Survey (USGS) scientists from the Coastal Change Hazards Project to participate in their second annual Hurricanes and Other Natural Disasters Expo held on June 5, 2010, in St. Petersburg, Florida. Three hundred and fifty people attended. The event was held to coincide with the beginning of hurricane season, which began June 1st and lasts until November 30th.

Oceanographer **Hilary Stockdon** gave a presentation on Coastal Change Hazards research, including what could happen to Pinellas County and its beaches if a hurricane were to strike. **Karen Morgan**, **Joseph Long**, and **Kara Doran** set up and staffed a booth that featured the "Shifting Sands" tank, an interactive model that demonstrates the dramatic coastal erosion that can occur during a hurricane or extreme storm event. Representatives from the National Weather Service, American Red Cross, Pinellas County Emergency Management Services, Pinellas County Communications Department, and Bay News 9, who also held information seminars at the event, joined the USGS at the Expo.

"The goal of the Expo is to provide awareness, so that the public does not become complacent and is prepared for the unexpected," said **Pam Bittaker**, project manager for the Science Center of Pinellas. "USGS has a lot to do with our environment, and the hurricanes actually do quite a bit of damage to our environment, so I thought it would be a great idea to invite USGS to participate."

Stockdon focused on the extreme damage previously wrought by severe storms and the changes they can bring to the coastal environment. Her presentation used numerous prestorm and poststorm photos of areas that had been hit by hurricanes to show the audience that structural damage during hurricanes is not only due to hurricane-force winds but also to sediment movement from coastal erosion.

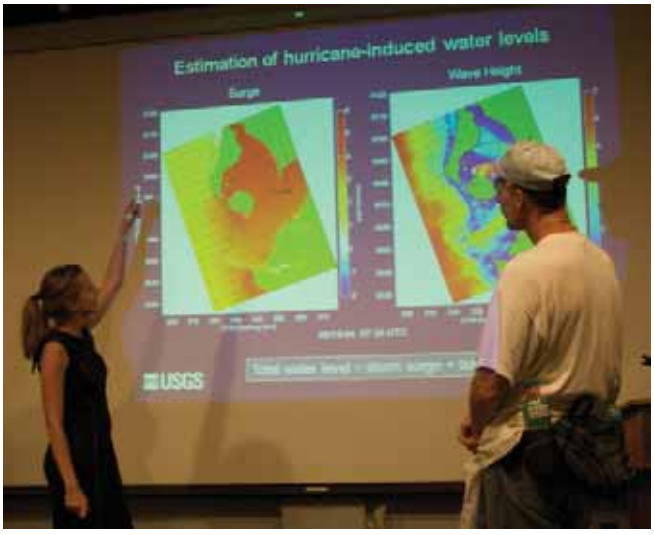
"People always think of hurricane hazards as wind and flooding, but it's also important for them to understand that land moves during hurricanes; waves and currents move sand, covering roads and eroding beaches," said **Stockdon**. **Stockdon** also defined concepts such as inundation, when an island is completely submerged under the rising storm surge, and overwash, when waves exceed the elevation of the dune and sand is transported across the island. Images and lidar (light detection and ranging) graphics were used to show areas where sediment eroded or accumulated because of overwash, as well as other storm-induced coastal changes, such as how the shape of a barrier island can change as a result of a storm. (Lidar is an aircraft-based remote sensing system that determines distance to an object or surface using laser pulses.) These data enable scientists to understand why diffferent beaches respond differently to storms, and to provide people with information as to why certain areas are better than others at accumulating sand.

***Kara Doran** rebuilds the beach of the Shifting Sands tank, a model that demonstrates coastal erosion.*

"Interacting with the public at these events is vital," said **Morgan**. "We need to do as much as we can to educate our neighbors about the impacts of hurricanes on our beaches and changes to coastal environments due to extreme storms."

At the booth, the display and shifting sands tank were a big hit. USGS scientists talked to visitors constantly throughout the day. Pinellas County residents were most

(Coastal Change Awareness continued on page 15)



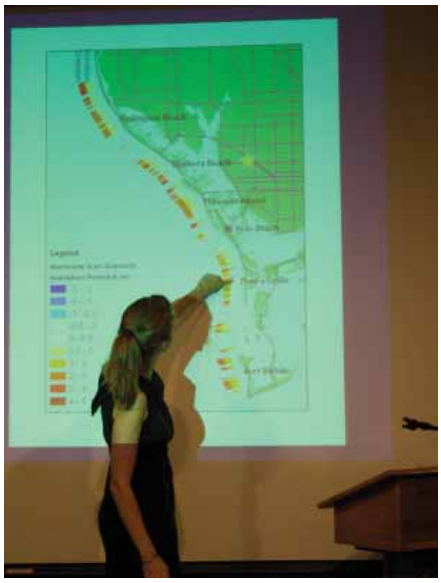
***Hilary Stockdon** (left) explains a model that shows what would happen to Pinellas County if a Category 3 hurricane were to make landfall in the region.*

(Coastal Change Awareness continued from page 14)

interested in the storm-surge-inundation potential graphic that illustrates what could happen if a Category 3 hurricane were to make landfall in the Pinellas County region, looking for their homes and favorite beaches to see how they would be affected. "It turned a light on in some people's minds when they saw maps of overwash and inundation and then saw their house," said **Stockdon**. Booth visitors gained information about previous hurricanes, saw examples of coastal change, and learned about scientific models that predict what might happen as a result of a hurricane.

An additional area of interest for attendees at the Expo was how a hurricane could affect where oil from the Deepwater Horizon spill could be deposited on beaches. One of the USGS models presented showed the possible oiling of Pinellas County during a hurricane. Tides, surge, waves, and topography all play a part in where and how far inland water, and whatever is in the water, will move along the Gulf coastline. These factors were all included during scientific modeling efforts. The models are tools that scientists use to compare the island elevation with the elevation of hurricane-induced water levels to create maps of where oil might be deposited during a storm. In Pinellas County, the model shows that almost the entire barrier-island system would be inundated by storm surge, and if oil were in the area, the islands would be covered.

This was the first year in which USGS participated in the Expo, but we hope to return next year to share this information and any new findings with the public. Through participation in local events, we are contributing to public awareness about coastal vulnerability and hazards.



***Hilary Stockdon** shows the storm-surge-inundation potential for Pinellas County beaches.*

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